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SOIL CONSERVATION SERVICE

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# HOLDING WATER IN FARM PONDS

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# HOLDING WATER IN FARM PONDS <sup>1</sup>

By H. N. Holtan, agricultural engineer, Soil Conservation Service--  
Research

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## INTRODUCTION

Increasing popularity and extended uses of farm ponds during recent years have resulted in some marked changes in design. Larger quantities of water are now being impounded. Increased heads are needed to provide water for supplemental irrigation, stock watering, or suitable habitat for fish. These increased heads place greater loads upon the pond floor. The problem of sealing is thereby made more complex.

Research was undertaken at the Soil and Water Conservation Research Project at Blacksburg, Va., <sup>2</sup> to determine economical and practical methods of sealing soils to hold and support greater heads of water in farm ponds. A review of published data and a report of laboratory research has been published.<sup>3</sup> Some essentials of the report are as follows:

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<sup>1</sup>This paper is a joint contribution of Soil Conservation Service--Research, U. S. Department of Agriculture, and the Agricultural Engineering Department, Virginia Agricultural Experiment Station, Blacksburg, Va.

<sup>2</sup>Research by Virginia Agricultural Experiment Station in cooperation with Soil Conservation Service, U. S. Department of Agriculture.

<sup>3</sup>HOLTAN, H. N. SEALING FARM PONDS. Agr. Engin. 31: 125-130, 133-, 134, illus. 1950.

1. Soils other than clay can be made watertight by compaction.
2. Maximum compaction can be obtained only when the soil is at optimum moisture.
3. The best proportions of soil fractions for sealing and support are at least 70 percent of sand, not more than 30 percent of clay, and silt as needed to improve gradation of particle size.
4. Although clays are relatively impervious to water in their natural state, they lack the stability needed to support great heads of water. They do not compact easily or permanently.
5. Percolation varies:
  - a. directly with head of water
  - b. inversely with thickness of soil layer
  - c. inversely with the degree of compaction
6. Greater heads of water need greater thicknesses of soil mantle to support them.

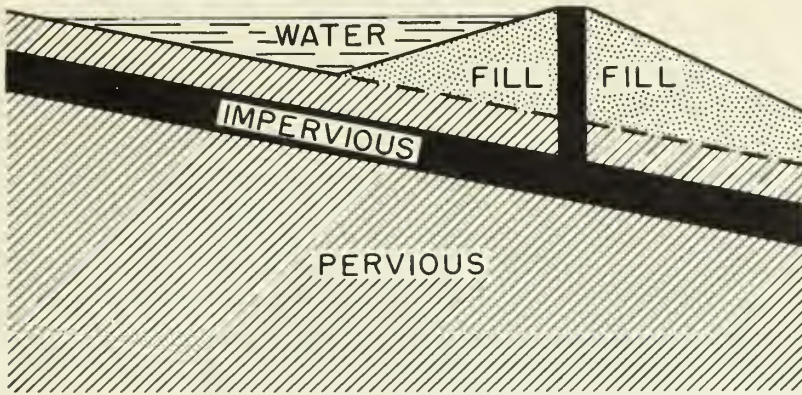
## PRINCIPLES OF SEALING FARM PONDS

These findings show that soils other than clay can be used for holding water, and with even better results. In order to use this information, it is necessary to explain three basic principles of farm pond seals; namely, the core-wall, wet-side seal, and bag types. Fundamental differences in these principles of farm pond design are illustrated in figure 1.

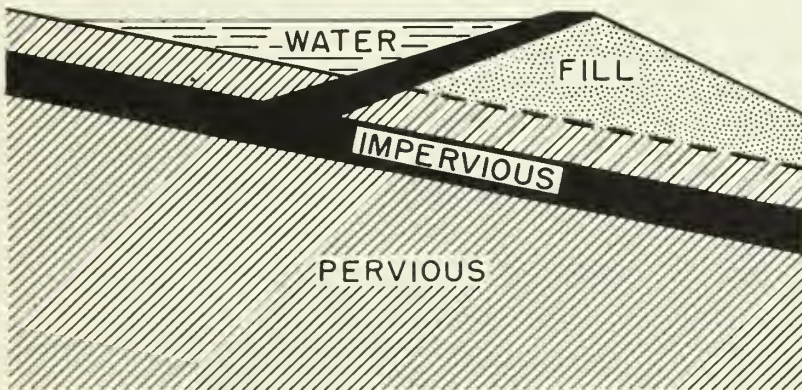
### Core-Wall Design

The familiar core-wall construction has been used for many years. An impervious core is keyed to an existing subsurface impervious layer and extended upward as the earth-fill dam is created. This type of construction can be used only at sites having an existing water impervious layer. Three major disadvantages of this design are:

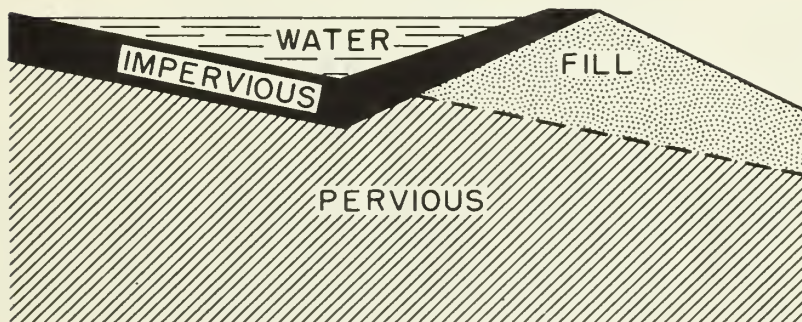
1. The inaccessibility of the completed core wall for any needed repairs.
2. The difficulty of checking the continuity of the subsurface impervious layer.
3. The inability of that portion of the soil mantle above the impervious layer to contribute anything toward the support needed for great heads of water.



A.—CORE-WALL TYPE



B.—WET-SIDE SEAL TYPE



C.—BAG TYPE

FIGURE 1.— THREE DESIGNS FOR FARM  
POND CONSTRUCTION:

- (A) Core-wall type, demanding sub-surface tight layer.
- (B) Wet-side seal, keyed to tight layer.
- (C) Bag type, wherein a sealed layer over the pond floor and up the face of the dam is created.

## Wet-Side Seal Design

To overcome the disadvantage of inaccessibility of the core-wall, the sealing wall is placed on the wet-side surface of the earth-fill dam as an impervious slab. This slab is extended downward until it intercepts the existing impervious layer, thus cutting off the horizontal seepage. The slab or seal is similar to the laminated wet-side face made by the blade of a bull-dozer when this implement is used to push earth up the wet side of the fill during construction. Laminations thus formed provide successive obstacles to seepage. The wet-side seal is readily accessible for repairs if needed.

## Bag Design

The 'bag' type of pond is suited to sites where the impermeable layer is not continuous or where no such layer is present. A sealed layer is provided at the ground surface over the entire pond floor and continues up the wet side of the earth-fill dam. Advantages of this design are:

1. The ready accessibility of the impervious layer for observation and repairs.
2. The utilization of the entire soil mantle as support for greater heads of water. (This becomes critical when pervious rock strata or other porous materials lie near the surface.)
3. The removal of some stringent limitations on possible pond sites.

## THE SOIL INVENTORY

No single design can be expected to apply to all conditions. Economics, materials, and conditions should determine the principle to be applied.

A thorough examination of the soil should be made over the entire pond area. This examination provides an inventory of the materials from which the pond will be constructed. In making it, the sealing and supporting qualities of soils in general should be kept in mind. The following points together with occasional reference to the research findings mentioned in the Introduction and to the discussion under 'Soil Sealing' will be of help:

1. The soil should be probed to a depth of at least 2 feet below what will be the sealed layer after completion of the pond.
2. The sealing qualities, supporting capacity, and relative position of the various textural horizons in the profile should be noted.

3. The type of construction to be used is largely dependent upon the result of the soil inventory.
  - a. A tight layer of clay 2 feet or more thick is suitable for the core-wall type of construction.
  - b. A tight layer less than 2 feet thick will need support from an underlying soil that is compact and firm.
  - c. Soil profiles of less than 2 feet in thickness that lie above seamy rock or extremely porous substrata lend themselves only to the bag type of construction. Soil will have to be hauled in and a seal obtained by additives, by compaction, or both.
4. Where the soil mantle in the pond area is limited, a borrow pit should be located and the sealing qualities of the material carefully determined.
5. The best method of sealing the soils that need sealing should be determined.
  - a. Clays are most responsive to dispersion but need greater thicknesses, when dispersed, for support of loads.
  - b. Compaction is not successful with clays but works very well with other soils. Results of compaction improve as the soil approaches the proportions of 'clay bonding' (see 'Soil Sealing').
  - c. Bentonites work better if about 10 to 15 percent of sand is present. Good stable soils are needed since bentonite tends to weaken the supporting capacity of a soil.
  - d. Any filter will plug up if heavily used; consequently, our chief concern is stability for support. Sandy soils provide good support and through filtering of inwashed fines will seal themselves if given time and a soil-bearing inflow to the pond.

### SELECT DESIGN TO FIT SOIL INVENTORY

1. There would be no point in designing a core-wall pond at a site where no impervious layer is present. Conversely, it would be uneconomical to use the bag type of design where the core wall is applicable. These designs are purely 'tools of the trade' to be selected and used as conditions indicate.

2. If the soil inventory reveals the presence of an impervious layer with at least 2 feet of soil beneath it, and if a good supply of impervious materials for a core wall is available, the center core wall would be the type to use. If the material for the core is not fully suitable, the wet-side seal would facilitate later repairs.

3. If the impervious layer is absent or not continuous over the pond area, or if the thickness of such a layer above an underlying porous stratum is less than 2 feet, the bag type of design is safest. In this type of construction, soil manipulation or treatment is usually needed.

## SOIL SEALING

### Clay Bonding

Experimentation and actual field practice indicate that the best soil mixture for pond construction consists of 70 to 95 percent of sharp, graduated sand; 30 percent to as low as 5 percent of sticky clay; and enough silt, as needed, to provide a good gradation of particle sizes from coarse sand to clay.

A practical method of recognizing approximately this condition in the field has been reported by David Dixon, Work Unit Conservationist, Soil Conservation Service, at Kinston, N. C. In this method, water and soil are placed in a 1-quart straight-sided jar and shaken vigorously for a few minutes. The next day the depths of the sand, silt, and clay layers that settle are measured separately and the percentage of each is roughly computed.

An approximate field analysis of this kind is perhaps more reliable than a precise mechanical analysis in the laboratory. The effective size in sealing is not often mono-particle, hence a quick test in the field more nearly represents the actual. Some standardization is desirable, however, such as:

1. Fill the 1-quart glass jar approximately one-third full of soil and add water until the jar is two-thirds full.
2. Let the soil and water stand for 60 minutes before shaking. The time of wetting or soaking is important and should be constant for all soils.
3. Shake the sample by up-ending eight times per minute for 2 minutes.
4. Let the sample stand undisturbed for 24 hours.
5. Measure the total height of the sediment and the height or thickness of each discernible texture (sand, silt, and clay).
6. Express the height or thickness of each texture in percent of total sediment.

With the accumulation of field experience, this method has possibilities. For example, the clarity of the demarcation between textures is a clue to the gradation of particle size. Clear demarcations indicate size lapses whereas gradual transitions indicate good gradation.

A rule-of-thumb method used by commercial dirt-movers is quoted.<sup>4</sup>

'If a sample of well graded material is wetted and squeezed in the hand, the following characteristics will be noted:

- a. The soil is extremely gritty;
- b. It can be formed into definite shapes that retain their forms even when dried;
- c. If the clay alone adheres to the hands, it will only be enough to discolor them slightly;
- d. If more than enough soil to discolor the hands adheres to them, it will consist of both sand and clay instead of clay alone; and
- e. When the wetted sample is patted in the palm of the hand, it will compact into a dense cake that cannot be penetrated readily with a blunt stick the size of a lead pencil.'

The proportions are referred to as 'clay bonding.' They represent the ideal mixture for sealing and stability. Soils having less sand can also be manipulated and compacted, but heavier compaction loads are needed to seal the soil and greater thicknesses are needed for support of the water load.

### Soil Compaction

Soil compaction is the most successful of the treatments tried to date for sealing soils other than clay. Upon completion of a bag-type pond, the entire area of the pond that will be in contact with water is loosened and stirred to a depth of at least 6 inches. This can be done with farm machinery. The soil, before compacting, must then be brought to a condition of moisture just above good tilth.

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<sup>4</sup>SEAMAN MOTORS. SOIL STABILIZATION METHODS. Seaman Motors Co., Milwaukee, Wis., Bul. 24, 85 pp., illus. 1946.

Compaction can be done by sheepfoot rollers or other heavy rolling equipment, or by cattle trampling. When machinery is used, the moisture content of the soil must be just short of the amount where free water appears under compaction. If free water should appear, drainage for a period of 24 hours will usually dry the soil to the optimum moisture content. When cattle are used, they should be concentrated in the area while the soil is slightly on the wet side and kept in the area until the soil passes through the optimum moisture condition and until compaction is achieved. Loosening and stirring the soil before wetting is especially essential where cattle are to be used. This permits compaction from the bottom up, thus giving a thicker compacted layer.

The greater the head of water anticipated, the greater is the need for good compaction. Heads of 15 feet or more of water demand the use of heavy machinery for proper soil compaction. Optimum moisture is extremely important to obtain a dense compaction. The appearance of the completed job may not always indicate whether this moisture was present. Soils 'compacted' when dry may appear solid after compaction, but when submitted to wetting they will melt down and become completely unconsolidated. A soil compacted at optimum moisture appears springy under the roller but the density is actually greater than that of soils compacted in a dry condition.

These same principles can be applied in the construction of 'core walls' or 'wet-side seals' from other than clay material. Clays, however, do not compact easily, and if they are compacted they soon loosen up again.

### Bentonites

Bentonites are commercial clays of high swelling capacity. When wet, they handle in a manner similar to that of cup grease; like grease, they are watertight but will not withstand pressure. Too heavy an application or improper mixing with the soil will reduce the supporting capacity to the point of failure and blow-holes will occur in pond-bottoms having shallow soils. Bentonites, therefore, need the presence of a certain amount of sand to provide stability; and the gradation of particle sizes becomes very important since the extremely fine-textured bentonites cannot bridge large interstices when appreciable heads of water are applied. A well-designed field test should be made, or the manufacturer should be consulted before bentonite is applied.

### Dispersion.

Dispersion agents such as the sodium salts break up the soil aggregates and create fines. Although dispersion reduces the seepage of clays, the stability or supporting capacity of the clay is reduced at the same time to practically zero. Dispersion should be used, therefore,

only where the soil mantle over cavernous or seamy substrata is several feet in thickness. Small heads of water, up to 3 or 4 feet, can be held successfully by thin mantles of clay over seamy rock but blowouts occur under greater heads.

Puddling the soil by cattle or machinery; i. e., working excesses of water with soil into a paste or soup, will also disperse many soils, but this condition should be sharply distinguished from the compaction process previously explained. Although puddling achieves a certain amount of compaction, the excess water that clings to the soil particles retards and obstructs compaction. The result is a less stable and less dense soil than would be obtained if the soil were compacted at optimum moisture.

### SUMMARY

1. A thorough soil inventory should be made of the pond area.
2. The depth of excavation should be calculated to leave at least 2 feet of soil below what is to be the sealed layer.
3. The design of construction should fit the conditions:
  - a. If a reliable tight (impervious) layer occurs at least 2 feet above any seamy or porous substrata, the core-wall type is perhaps the most economical.
  - b. If materials for the core wall are not of the best, a wet-side seal keyed into the tight layer will lend itself more readily to repairs.
  - c. If the impervious layer is absent, if it is thin and lies immediately above porous or seamy rock, or if rock outcroppings occur, the bag type of design can be used. The rock outcrops can be capped with soil and the depth of the soil layer can be controlled. Furthermore, all of the soil thickness is used for support since the sealed layer is at its surface.
4. A thorough soil inventory should be made of any borrow pit outside of the pond area that will be used as a source of material for constructing the dam or for building up the thickness of shallow soil mantles in the pond area.
5. Sealing the soil is less expensive if adequate provisions for sealing are made in the original design.
6. The elimination of the core wall tends to offset the cost of soil manipulation.

7. The soil should be loosened and stirred to a depth of at least 6 inches. It should be brought to a state of optimum moisture by artificial means or by natural precipitation or drying. (Optimum moisture is the condition in which the soil is too wet for good tilth but not wet enough to exude free water during the compaction process.) The soil may be compacted thoroughly by cattle for heads of 6 feet or less, but machinery should be used for heads of water 7 feet or greater.
8. It is easier and cheaper to haul in 30 percent of clay to correct a 6-inch layer of sand to the proportions of clay bonding than it is to haul in 70 percent of sand to correct a similar layer of clay. Sands may even be corrected by natural inwash of clays and silts. This process can be aided by occasional plowing of the pond bottom to mix the inwashed materials with the sand of the pond bottom.
9. Clays are a greater problem than other soils. They do not compact readily or permanently. Since clays are unstable, a thicker layer is needed to support the weight of water. Dispersion of clays in cases of unlimited soil depths helps to seal the soil. A 1- or 2-foot layer of dispersed clay, however, is not dependable for support.
10. Bentonites work best for well-graduated sandy soils. The quality and grade of bentonite used is a governing factor in application. The manufacturer usually is willing to make tests and furnish recommendations of use on request.
11. Building a pond to hold water is definitely an engineering problem. The available materials should be used to the best of their capacities. Forethought and planning may make the difference between success and failure. The cheapest pond is a full one.